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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.	
First Inventor or Application Identifier	Jwo-Min Wang
Title	METHOD FOR ACHIEVING UNIFORM EXPANSION OF DIELECTRIC PLATE
Express Mail Label No.	EJ197300887US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

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1. [X] * Fee Transmittal Form *(e.g., PTO/SB/17)* *(Submit an original and a duplicate for fee processing)*
2. [X] Specification [Total Pages 13] *(preferred arrangement set forth below)*
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
3. [X] Drawing(s) *(35 U.S.C. 113)* [Total Sheets 3]
4. Oath or Declaration [Total Pages 3]
   a. [X] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 C.F.R. § 1.63(d)) *(for continuation/divisional with Box 16 completed)*
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

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5. [ ] Microfiche Computer Program *(Appendix)*
6. Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all necessary)*
   a. [ ] Computer Readable Copy
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ACCOMPANYING APPLICATION PARTS

7. [X] Assignment Papers (cover sheet & document(s))
8. [ ] 37 C.F.R.§3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
9. [ ] English Translation Document *(if applicable)*
10. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
11. [ ] Preliminary Amendment
12. [X] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
13. [ ] * Small Entity Statement(s) *(PTO/SB/09-12)* [ ] Statement filed in prior application, Status still proper and desired
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Name (Print/Type)	Wei Te Chung	*Registration No. (Attorney/Agent)*	43,325
Signature		*Date*	May 24, 1999

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Inventors: Jwo-Min Wang

Shih-Wei Hsiao

SPECIFICATION

METHOD FOR ACHIEVING UNIFORM EXPANSION OF DIELECTRIC PLATE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to a method for achieving uniform expansion of a dielectric plate and a dielectric plate made thereby.

2. The Prior Art

A central processing unit (CPU) of a computer is mounted to a main computer board by means of a connector. Conventionally, the CPU connector has contacts extending beyond top and bottom faces thereof for electrical engagement with pins of the CPU and conductive traces of the main board. The contacts are soldered to the main board by a through hole technique. Such a connector structure occupies a substantial amount of space on the main board and requires a sophisticated process to mount the connector thereon.

A ball grid array (BGA) connector effectively overcomes the problems discussed above. As shown in Figure 3 of the attached drawings, a BGA connector 4 comprises a dielectric base plate 40 defining a number of bores (not labeled) therein between top and bottom faces thereof for receiving and retaining conductive contacts 41. Each contact 41 has a solder support section 42 extending beyond the bottom face of the base plate 40. A solder

ball 3 is attached to the solder support section 42 by preheating the solder support section 42.

The contacts 41 are aligned with contact pads 50 formed on a circuit board 5 whereby when the base plate 40 is properly positioned on the circuit board 5, the solder balls 3 contact the corresponding contact pads 50. By means of heating, the solder balls 3 are molten and then solidify to be fixed to the contact pads 50 of the circuit board 5. An efficient and effective method for soldering the connector 4 to the circuit board 5 is thus achieved.

However, since the base plate 40 of the connector 4 and the circuit board 5 are generally made of different material having different thermal expansion coefficients, heating the solder balls 3 to fix the contacts 41 to the contact pads 50 will result in different amounts of expansion between the circuit board 5 and the base plate 40 leading to an undesired strain on the solder balls 3.

Furthermore, the base plate 40 is usually made by means of injection molding. During the molding process, plasticized dielectric material flows into a mold. Due to the complicated configuration of the base, a non-uniform distribution of the molecules of the dielectric material results leading to different amounts of thermal expansion in different directions of the base plate 40 when the base plate 40 is heated during a BGA soldering process. Such nonuniform thermal properties further complicate the above-mentioned problem.

Thus, it is desired to provide a method for achieving uniform expansion of a dielectric plate.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide a method for achieving uniform expansion of a dielectric plate.

Another object of the present invention is to provide a method for achieving substantially uniform thermal expansion between a connector and a circuit board to which the connector is mounted.

A further object of the present invention is to provide a base plate of a BGA connector which has substantially uniform thermal expansion properties.

A still further object of the present invention is to provide an injection-molded base plate of a BGA connector having limited warpage after being cured.

To achieve the above objects, a method is provided for achieving uniform expansion of a dielectric plate made by injection molding. The method comprises the steps of forming core pins having a rhombic cross section at predetermined positions inside a mold for injection-molding the plate, injecting plasticized dielectric material into the mold wherein the core pins guide the plasticized material flow for properly orienting molecules of the dielectric material, and curing and forming the dielectric plate in which rhombic holes corresponding to the core pins are formed. The properly oriented molecules of the dielectric material and the rhombic holes reduce the difference between thermal expansion coefficients in longitudinal and lateral directions of the plate thereby achieving uniform expansion thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be apparent to those skilled in the art by reading the following description of a preferred embodiment thereof, with reference to the accompanying drawings, in which:

Figure 1 is an exploded view of an electrical connector made by a method in accordance with the present invention, a base plate of the connector being mounted to a circuit board while a cover thereof is detached from the base plate;

Figure 2 is a top plan view of the base plate of the electrical connector made in accordance with the method of the present invention; and

Figure 3 is an exploded view of a conventional connector mounted to a circuit board.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings and in particular to Figure 1, an electrical connector 1 made by a method in accordance with the present invention comprises a base plate 11 mounted to a circuit board 5 and a cover 10 movably mounted on the base plate 11 for retaining an electronic device, such as a CPU (not shown), thereon. The base plate 11 and the cover 10 are made of dielectric material such as a liquid crystalline polymer (LCP) by injection molding.

A plurality of bores 12 arranged in rows is defined in the base plate 11 for receiving and retaining conductive contacts 2 therein. A plurality of through holes 13 is defined in the cover 10 corresponding to the bores 12 of the base plate 11 for receiving conductive pins of the electronic device therein.

The pins extend through the holes 13 and partially extend into the corresponding bores 12 whereby when the cover 10 is moved with respect to the base plate 11, the pins are brought into engagement with the corresponding contacts 2 of the base 11.

Each contact 2 has a mating section 21 retained in the corresponding bore 12 for engagement with the corresponding pin of the electronic device and a solder ball support section 20 exposed to a bottom of the base plate 11 for supporting a solder ball 3 thereon with the solder ball 3 projecting beyond the bottom of the base plate 11.

The circuit board 5 has a number of conductive pads 50 formed thereon corresponding to the contacts 2. The base plate 11 is properly positioned on the circuit board 5 and the solder balls 3 contact the corresponding conductive pads 50 of the circuit board 5. By heating the solder balls 3, the solder balls 3 become molten and then solidify to fix the contacts 2 to the corresponding conductive pads 50 of the circuit board 5.

Since the dielectric material is in general not uniformly distributed throughout the whole base plate 11 and the cover 10 during the injection molding process and since the base plate 11 and the cover 10 are rectangular, when heated, the base plate 11 and the cover 10 are subject to different thermal expansion coefficients in different directions, such as a longitudinal direction and a lateral direction of the rectangle. Experimental data of a sample of the base plate 11 indicates that the thermal expansion coefficient in the lateral direction (α_x) is 50×10^{-6} mm/mm·°C and the thermal expansion coefficient in the longitudinal direction (α_y) is 5×10^{-6} mm/mm·°C. The difference between α_x and α_y is substantial.

To overcome such a problem, in a preferred embodiment, a plurality of rhombic holes 14 is formed in the base plate 11. The distribution, location, and size of the rhombic holes 14 are carefully selected whereby the difference between the thermal expansion coefficients in both the longitudinal direction (α_y) and the lateral direction (α_x) is substantially reduced. Core pins having rhombic cross sections are provided in a mold for injection molding the base plate 11 resulting in the formation of the rhombic holes 14. The rhombic holes 14 are oriented such that a major diagonal direction thereof is substantially parallel to a flowing direction of the dielectric material that forms the base plate 11 whereby the plasticized dielectric material, when flowing in the mold, is guided by the core pins to fill the mold leading to regular arrangement of the molecules of the dielectric material in the base plate after being cured. A small circle 15 representing a gate of the mold is provided in the base plate 11.

The regular arrangement of the molecules of the dielectric material and the holes 14 formed after the mold is removed substantially reduce the thermal expansion coefficient in the lateral direction (α_x) and slightly increase the thermal expansion coefficient in the longitudinal direction (α_y). Experimental data shows that for the same sample discussed above with rhombic holes 14 formed therein having a pattern of hole distribution as shown in Figure 2, the thermal expansion coefficient in the lateral direction (α_x) is 22×10^{-6} mm/mm·°C and the thermal expansion coefficient in the longitudinal direction (α_y) is 13×10^{-6} mm/mm·°C. Hence, the difference therebetween is substantially reduced.

Furthermore, it is noted that the thermal expansion coefficient for a typical circuit board is $17\text{-}20\times10^{-6}$ mm/mm·°C. The base plate 11 made by

the method of the present invention has thermal expansion coefficients in both longitudinal and lateral directions approximately equal to that of the circuit board. Therefore, a strain caused in the solder balls 3 due to different thermal expansions between the base plate 11 and the circuit board 5 is minimized.

The rhombic holes 14 formed by the additional core pins provided in the mold during the injection molding operation provide the following advantages. The plasticized dielectric material that forms the base plate 11 may be completely and uniformly filled in the mold due to the presence of the core pins leading to uniform mechanical properties. Furthermore, warpage that often occurs in the injection-molded articles is reduced due to the uniform distribution of the dielectric material.

It should be noted that the holes 14 may be blind holes or through holes. The exact shape of the holes 14 may vary dependent upon the configuration of the base plate to be molded. If desired, some of the holes 14 can be alternately arranged in rows as show in Figure 2.

To summarize, the present invention provides a method for achieving uniform expansion of a dielectric plate comprising the following steps:

(1) providing a mold for injection-molding the dielectric plate;

(2) determining locations, sizes and shapes of core pins formed inside the mold;

(3) injecting a plasticized dielectric material into the mold to form the dielectric plate wherein the core pins guide a flow of the plasticized dielectric material to uniformly fill the mold with molecules of the dielectric material properly oriented; and

(4) curing and forming the dielectric plate in which holes corresponding to the core pins are formed.

Although the present invention has been described with reference to the best mold thereof, it is apparent to those skilled in the art that a variety of modifications and changes may be made without departing from the scope of the present invention which is intended to be defined by the appended claims.

WHAT IS CLAIMED IS

1. A method for achieving uniform expansion of a dielectric plate comprising the following steps:

(a) providing a mold for injection-molding the dielectric plate;

(b) determining locations, sizes and shapes of core pins of the mold;

(c) injecting a plasticized dielectric material into the mold to form the dielectric plate wherein the core pins guide a flow of the plasticized dielectric material whereby molecules of the dielectric material are properly oriented; and

(d) curing and forming the dielectric plate in which holes corresponding to the core pins are formed.

2. The method as claimed in Claim **1**, wherein the core pins have a rhombic cross section which form rhombic holes in the plate.

3. The method as claimed in Claim **1**, wherein at least some of the core pins are alternately arranged in rows whereby the holes formed in the plate are also alternately arranged in rows.

4. The method as claimed in Claim **1**, wherein the dielectric material is a liquid crystal polymer.

5. The method as claimed in Claim **1**, wherein the plate is rectangular, and wherein the thermal expansion coefficient of the plate in a longitudinal direction is 13×10^{-6} mm/mm·°C and the thermal expansion coefficient of the plate in a lateral direction is 22×10^{-6} mm/mm·°C.

6. The method as claimed in Claim **5**, wherein the plate is a base plate of a ball grid array type connector mounted on a circuit board, and wherein the circuit board has a coefficient of thermal expansion of $17\text{-}20\times10^{-6}$ mm/mm·°C substantially corresponding to the longitudinal and lateral direction thermal expansion coefficients of the plate.

7. The method as claimed in Claim **1**, wherein the plate is a base plate of a ball grid array type connector mounted to a circuit board made of a material having a thermal expansion coefficient substantially corresponding to the thermal expansion coefficient of the plate.

8. The method as claimed in Claim **1**, wherein at least some of the holes are blind holes.

9. The method as claimed in Claim **1**, wherein the holes formed in the plate have different sizes.

10. The method as claimed in Claim **1**, wherein the core pins have an elliptical cross section forming elliptical holes in the plate.

11. The method as claimed in Claim **1**, wherein the core pins are arranged to guide the flow of the dielectric material to completely and uniformly fill in the mold.

12. An electrical connector comprising a base plate fixed to a circuit board and a cover movably mounted to the base plate, the base plate defining contact receiving bores for receiving and retaining conductive contacts therein, the contacts being soldered to corresponding conductive pads formed on the circuit board by means of a ball grid array technique, the

cover being adapted to retain an electronic device thereon, pins of the electronic device extending through holes defined in the cover and partially extending into the contact receiving holes whereby when the cover is moved with respect to the base, the pins are brought into contact and thus electrically engage with the contacts, wherein the base plate is made of a dielectric material by means of injection molding with a mold comprising core pins whereby the base plate molded thereby defines a plurality of holes in a predetermined pattern for reducing a difference between thermal expansion coefficients of the base plate in first and second directions substantially normal to each other.

13. The electrical connector as claimed in Claim **12**, wherein the holes are rhombic with a major diagonal direction thereof being substantially parallel to a flowing direction of a plasticized fluid of the dielectric material.

14. The electrical connector as claimed in Claim **12**, wherein at least some of the holes formed in the plate are alternately arranged in rows.

15. The electrical connector as claimed in Claim **12**, wherein the dielectric material is a liquid crystal polymer.

16. The electrical connector as claimed in Claim **12**, wherein the base plate is substantially rectangular, and wherein the thermal expansion coefficient of the plate in the first direction is 13×10^{-6} mm/mm·°C and the thermal expansion coefficient of the plate in the second direction is 22×10^{-6} mm/mm·°C.

17. The electrical connector as claimed in Claim **12**, wherein the circuit board is made of a material having a thermal expansion coefficient substantially corresponding to the thermal expansion coefficient of the base plate.

18. The electrical connector as claimed in Claim **12**, wherein the holes formed in the base plate have different sizes.

19. The electrical connector as claimed in Claim **12**, wherein the holes defined in the base plate are elliptical with a major direction thereof being substantially parallel to a flowing direction of a plasticized fluid of the dielectric material.

20. An electrical assembly comprising a connector and a circuit board, said connector including at least a base plate retaining a plurality of conductive contacts thereto, each of said contacts being attached to the circuit board via a solder ball positioned at a tip of a tail portion of the contact, said base plate defining a plurality of holes around the contacts wherein said holes are designedly arranged to be properly located, dimensioned and shaped so that a thermal expansion coefficient of said base plate is modified to be substantially close to that of the circuit board for preventing breakage of said solder balls.

ABSTRACT

A method for achieving uniform expansion of a dielectric plate made by injection molding includes the steps of forming core pins having a rhombic cross section at predetermined positions inside a mold for injection-molding the plate, injecting a plasticized dielectric material into the mold wherein the core pins guide the plasticized material flow for properly orienting molecules of the dielectric material, and curing and forming the dielectric plate in which rhombic holes corresponding to the core pins are formed. The properly oriented molecules of the dielectric material and the rhombic holes reduce the difference between thermal expansion coefficients in longitudinal and lateral directions of the plate thereby achieving uniform expansion thereof.

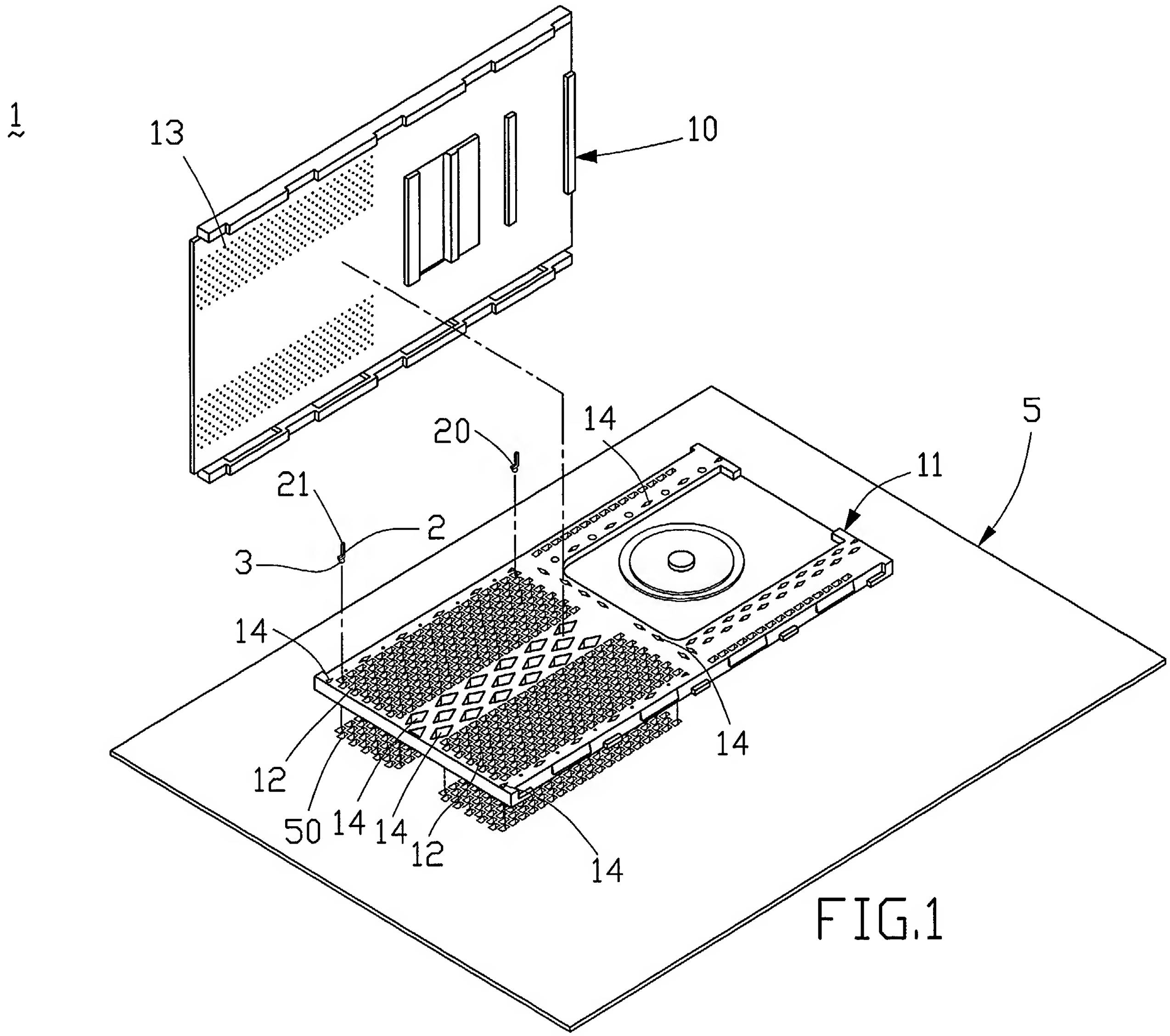

FIG.1

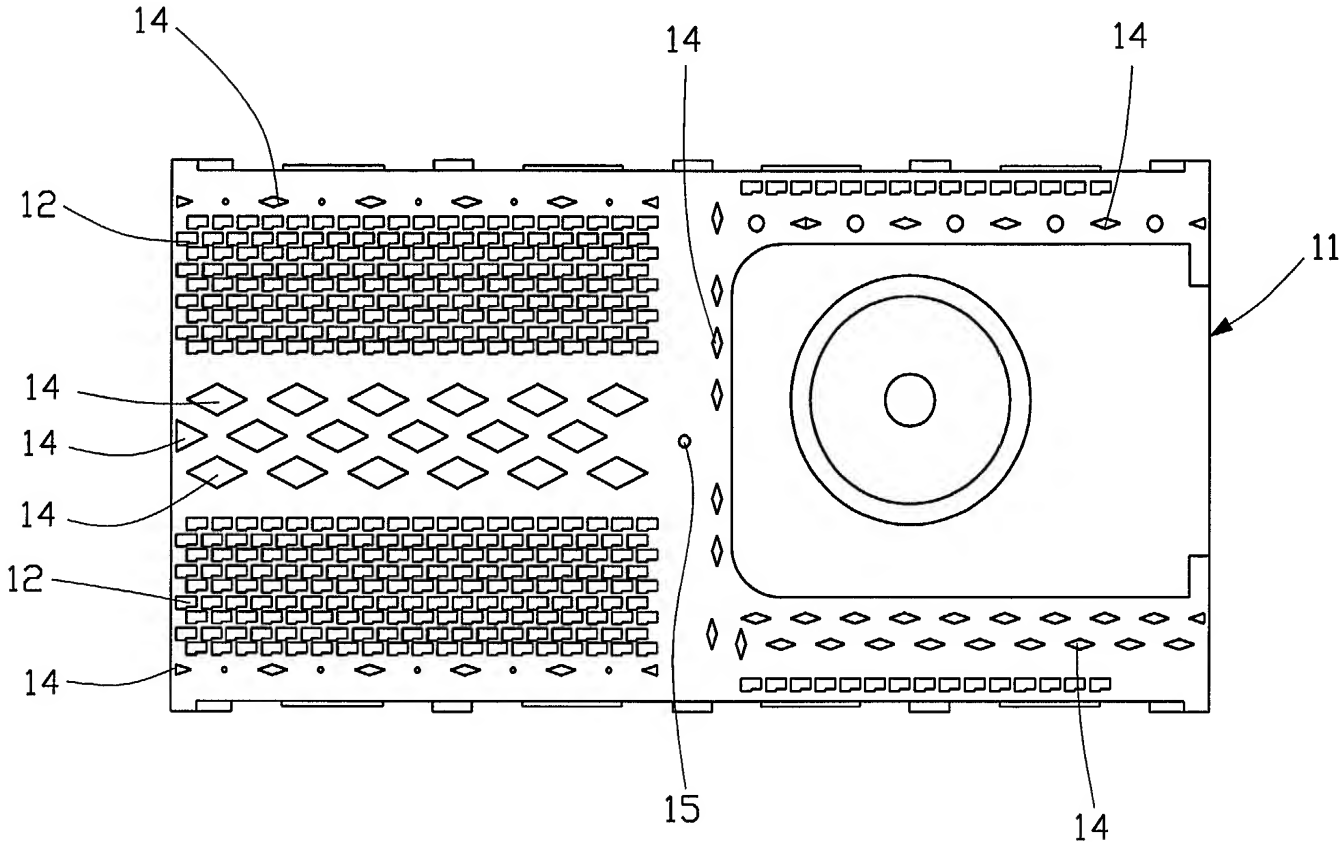

FIG.2

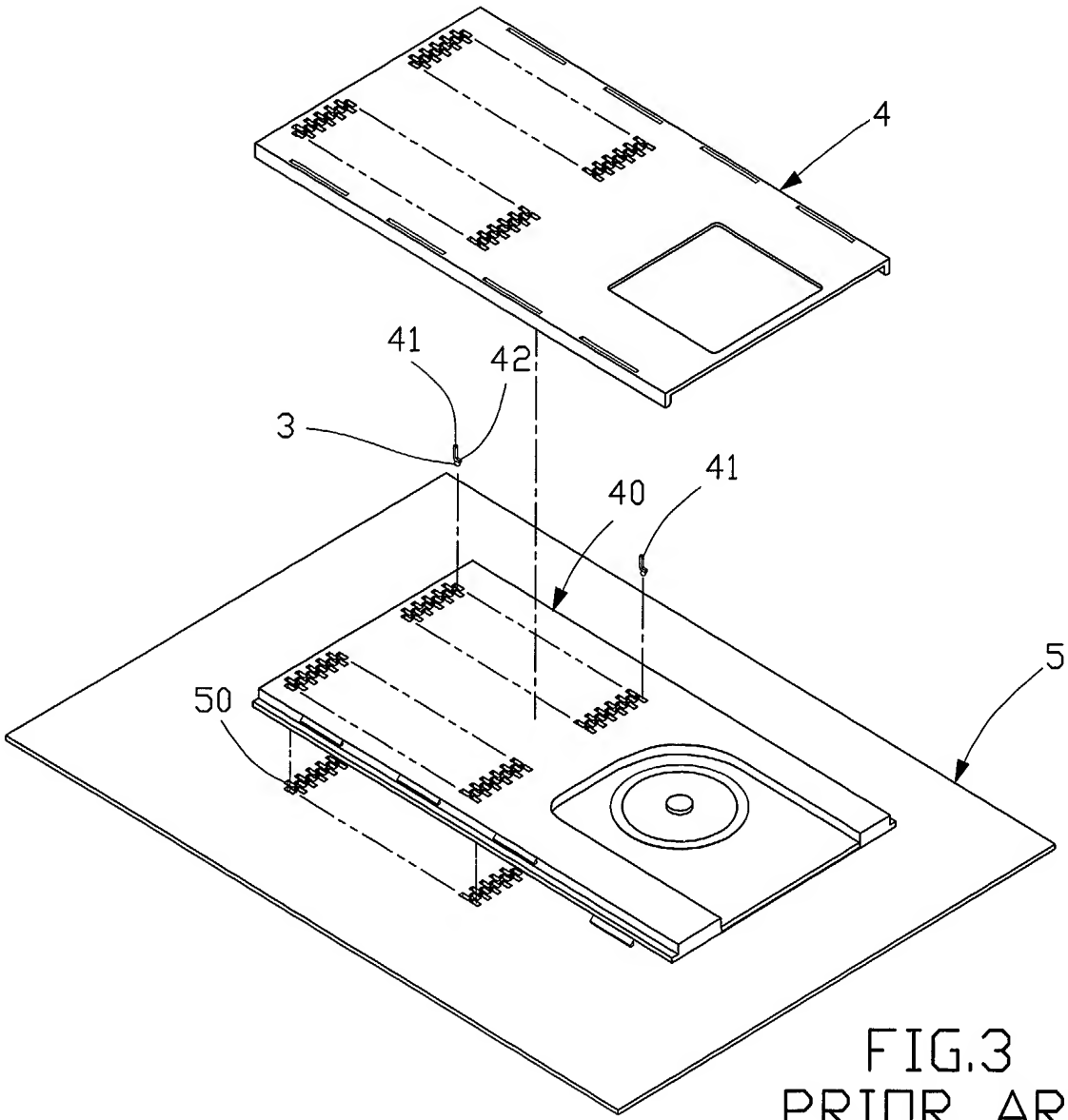

FIG.3
PRIOR ART

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☒ Declaration Submitted with Initial Filing OR ☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	
First Named Inventor	Jwo-Min Wang
COMPLETE IF KNOWN	
Application Number	/
Filing Date	
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD FOR ACHIEVING UNIFORM EXPANSION OF DIELECTRIC PLATE

(Title of the Invention)

the specification of which

☒ is attached hereto

OR

☐ was filed on (MM/DD/YYYY) _____ as United States Application Number or PCT International Application Number _____ and was amended on (MM/DD/YYYY) _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
87119235	Taiwan	Nov/20/98	☐	☒	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below

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U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

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☒ Registered practitioner(s) name/registration number listed below

Name	Registration Number	Name	Registration Number
Wei Te Chung	43,325		

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Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])	Family Name or Surname
Jwo-Min	Wang

Inventor's Signature	Jwomin Wang					Date	12/20/98
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Post Office Address							
City	Santa Clara	State	CA	ZIP	95050	Country	U.S.A.

☒ Additional inventors are being named on the 1 supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

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DECLARATION

ADDITIONAL INVENTOR(S)
Supplemental Sheet
Page 1 of 1

Name of Additional Joint Inventor, if any:	☐ A petition has been filed for this unsigned inventor						
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Shih-Wei			Hsiao				
Inventor's Signature	Shih-Wei Hsiao				Date	12/20/98	
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Post Office Address							
City	Santa Clara	State	CA	ZIP	95050	Country	U.S.A.

Name of Additional Joint Inventor, if any:	☐ A petition has been filed for this unsigned inventor						
Given Name (first and middle [if any])			Family Name or Surname				
Inventor's Signature					Date		
Residence: City		State		Country		Citizenship	
Post Office Address							
Post Office Address							
City		State		ZIP		Country	

Name of Additional Joint Inventor, if any:	☐ A petition has been filed for this unsigned inventor						
Given Name (first and middle [if any])			Family Name or Surname				
Inventor's Signature					Date		
Residence: City		State		Country		Citizenship	
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